

**INFORMATIONAL HEARING**  
**CLIMATE CHANGE AND WATER RESOURCES**

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**9:00 a.m.**  
**February 20, 2007**

***A Bibliography:  
Scientific Reports Regarding  
Climate Change and California Water***

**Significant State Agency Reports**

**California Department of Water Resources, *Progress on Incorporating Climate Change into Management of California's Water Resources* (2006)**

**Report Overview:** This report contains eight chapters that present progress and future directions on incorporating climate change science into management of California's water resources. It focuses on assessment methodologies and preliminary study results. The technical chapters of this report were peer-reviewed by experts from water resources-related agencies and research institutions. Policy implications and recommendations are beyond the scope of this report.

**California Energy Commission, *California's Water-Energy Relationship***

**Abstract:** In 2005, the California Energy Commission published a report, *California's Water-Energy Relationship* (CEC 700-2005-011-SF), that estimates the magnitude and intensity of water-related energy consumption by segment of the water-use cycle. Because water-energy is a new area of study, and data were not readily available, this report relied on a number of different data sources and methods to develop the magnitude and intensity estimates.

The current study reviewed and updated these estimates for the magnitude and intensity of water-related energy consumption by segment of the water-use cycle. This review indicates that while the data and methods used to prepare the Energy Commission's 2005 report were not perfect, they offered a reasonable starting place for prioritizing water-energy research and development, as outlined in the Energy Commission's *Integrated Energy Policy Report*. Further, this study provided adjusted water-energy proxies that are sufficient for informing policy and prioritization

of research and development investments. The study also describes important data gaps and includes the collection of primary data from water utilities and the disaggregation of data geographically and within water-use cycle segments. A greater understanding of the sub-segments of the water-use cycle offers an opportunity to more effectively target research and development decisions at the technology level, and a phased approach is recommended to continually refine water-related energy intensity estimates on an ongoing basis.

### **Abstracts of Significant Reports**

#### ***American Water Works Association Research Foundation, *Primer for Municipal Water Providers: Climate Change and Water Resources* (2005)***

**Abstract:** A primer for municipal water providers developed in 2005 to 1) introduce water utility managers to the science surrounding climate change; 2) suggest the types of impacts it can have on water resources; and (3) provide guidance on planning and adaptation strategies.

#### ***Cayan, D., A. Luers, M. Hanemann, G. Franco and B. Croes; *Scenarios Of Climate Change In California: An Overview; California Climate Change Center, Scripps Institution of Oceanography (San Diego, CA): 53* (2006)***

**Abstract:** In 2003, the California Energy Commission's Public Interest Energy Research (PIER) program established the California Climate Change Center to conduct climate change research relevant to the state. This Center is a virtual organization with core research activities at Scripps Institution of Oceanography and the University of California, Berkeley, complemented by efforts at other research institutions. Priority research areas defined in PIER's five-year Climate Change Research Plan are: monitoring, analysis, and modeling of climate; analysis of options to reduce greenhouse gas emissions; assessment of physical impacts and of adaptation strategies; and analysis of the economic consequences of both climate change impacts as well as the efforts designed to reduce emissions. Executive Order #S-3-05, signed by Governor Arnold Schwarzenegger on June 1, 2005, called for the California Environmental Protection Agency (CalEPA) to prepare biennial science reports on the potential impact of continued global warming on certain sectors of the California economy. CalEPA entrusted PIER and its California Climate Change Center to lead this effort. The "Climate Scenarios" analysis summarized here is the first of these biennial science reports, and is the product of a multi-institution collaboration among the California Air Resources Board, California Department of Water Resources, California Energy Commission, CalEPA, and the Union of Concerned Scientists. FINAL report from California Energy Commission, Public Interest Energy Research (PIER) Program, California Climate Change Center.

**K. Hayhoe, D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider, K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J. Lenihan, C.K. Lunch, R.P. Neilson, S.C. Sheridan, J.H. Verville, *Emissions Pathways, Climate Change, And Impacts In California*, Proceedings of the National Academy of Sciences**

**Abstract:** The magnitude of future climate change depends substantially on the greenhouse gas emission pathways we choose. Here we explore the implications of the highest and lowest Intergovernmental Panel on Climate Change emissions pathways for climate change and associated impacts in California. Based on climate projections from two state-of-the-art climate models with low and medium sensitivity (Parallel Climate Model and Hadley Centre Climate Model, version 3, respectively), we find that annual temperature increases nearly double from the lower B1 to the higher A1fi emissions scenario before 2100. Three of four simulations also show greater increases in summer temperatures as compared with winter. Extreme heat and the associated impacts on a range of temperature-sensitive sectors are substantially greater under the higher emissions scenario, with some interscenario differences apparent before midcentury. By the end of the century under the B1 scenario, heatwaves and extreme heat in Los Angeles quadruple in frequency while heat-related mortality increases two to three times; alpine/subalpine forests are reduced by 50–75%; and Sierra snowpack is reduced 30–70%. Under A1fi, heatwaves in Los Angeles are six to eight times more frequent, with heat-related excess mortality increasing five to seven times; alpine/subalpine forests are reduced by 75–90%; and snowpack declines 73–90%, with cascading impacts on runoff and streamflow that, combined with projected modest declines in winter precipitation, could fundamentally disrupt California's water rights system. Although interscenario differences in climate impacts and costs of adaptation emerge mainly in the second half of the century, they are strongly dependent on emissions from preceding decades.

**Luers, A. , D.R. Cayan, G. Franco, M. Hanemann, B. Croes and (2006). *Our Changing Climate: Assessing The Risks To California*; California Climate Change Center, Scripps Institution of Oceanography (San Diego, CA): 16 (2006)**

**Abstract:** This document summarizes the recent findings of the California Climate Change Center's "Climate Scenarios" project, which analyzed a range of impacts that projected rising temperatures would likely have on California. The growing severity of the consequences as temperature rises underscores the importance of reducing emissions to minimize further warming. At the same time, it is essential to identify those consequences that may be unavoidable, for which we will need to develop coping and adaptation strategies.

**Medellin, J. , J. Harou, M. Olivares, J. Lund, R. Howitt, S. Tanaka, M. Jenkins, K. Madani and T. Zhu; *Climate warming and water supply management in California*; California Climate Change Center, Scripps Institution of Oceanography, San Diego, CA (2006)**

**Abstract:** This paper examines economic water management adaptations, effects, and other implications of a GFDL-A2 year 2085 dry climate warming scenario for California's water supply system with estimated year 2050 water demands and land use. The GFDL-A2 year 2085 scenario was chosen because it is the driest of the four scenarios in the overall study. Economically adaptive water management activities for this climate scenario are compared with a similar modeling scenario with a continuation of the historical climate. The effects of population growth and land development alone to 2050 are developed and compared with those where dry climate warming also occurs. Overall, such a dry climate warming scenario would impose large costs and challenges on the state. While this scenario would severely affect the economies of some rural and agricultural regions of California, the state's overall predominantly urban economy would survive and remain largely unhindered by water supply limitations. The dry climate scenario reduces average annual water availability by 27%, which results in an average annual water scarcity of 17%. Statewide, average agricultural areas see water deliveries 24% lower than demand targets, and urban areas see an average of 1% less deliveries than their demand targets. However, there are great regional disparities. Southern California experiences almost all of the urban water scarcity. Economic water scarcity costs increase by \$118 million/year from 2020 to 2050, with population and land use change. Adding dry climate warming to 2050 water demands raises water scarcity costs by an additional \$121 million/year. Of the \$360 million/year in average water scarcity costs for 2050 with dry climate warming, \$302 million/year results from lost agricultural production and \$59 million/year is from urban water shortages. Of the \$302 million/year seen by agricultural water users, over two-thirds occur in the Tulare Basin and Southern California. Almost all urban water scarcity costs occur in urban Southern California, which has limited ability to increase water imports to accommodate growth without expanding the Colorado River or California Aqueducts. Dry climate warming imposes an additional increase of \$384 million/year in system operating costs. Statewide costs increase over \$100 million/year if interregional water transfers are limited to 2020 conditions, without climate warming. With the climate warming, the costs of policies limiting interregional water transfers increases to \$250 million/year. Although these costs are sizable, they remain a small proportion of California's economy (which is today \$1.5 trillion/year). However, the greater part of this cost is borne by rural parts of the state.

**Tanaka, S. K. , T. Zhu, J. R. Lund, R. E. Howitt, M. W. Jenkins, M. A. Pulido, M. Tauber, R. S. Ritzema and I. C. Ferreira; *Climate warming and water management adaptation for California.*" *Climatic Change* 76(3-4): 361-387 (2006)**

**Abstract:** The ability of California's water supply system to adapt to long-term climatic and demographic changes is examined. Two climate warming and a historical climate scenario are examined with population and land use estimates for the year 2100 using a statewide economic-engineering optimization model of water supply management. Methodologically, the results of

this analysis indicate that for long-term climate change studies of complex systems, there is considerable value in including other major changes expected during a long-term time-frame (such as population changes), allowing the system to adapt to changes in conditions (a common feature of human societies), and representing the system in sufficient hydrologic and operational detail and breadth to allow significant adaptation.

While the policy results of this study are preliminary, they point to a considerable engineering and economic ability of complex, diverse, and inter-tied systems to adapt to significant changes in climate and population. More specifically, California's water supply system appears physically capable of adapting to significant changes in climate and population, albeit at a significant cost. Such adaptation would entail large changes in the operation of California's large groundwater storage capacity, significant transfers of water among water users, and some adoption of new technologies.

**Weare, B. C.; *Global Climate Change Will Affect Air, Water In California; California Agriculture* 56(3): 89-96 (2002)**

**Abstract:** As we enter the 21st century, it is possible to reach beyond the headlines to describe what is now known about climate change. The Intergovernmental Panel on Climate Change evaluated the scientific aspects of global climate change; the current consensus is described in a recent series of reports. Since the 19th century, concentrations of atmospheric carbon dioxide, methane, nitrous oxide and sulfate aerosol dust have increased significantly. While there is scientific agreement that warming is occurring, the controversy now concerns the extent of subsequent impacts in the future. In California, the impacts of global warming are likely to include reduced water availability and quality, poorer air quality, associated economic consequences, biodiversity shifts and health effects. The changes are expected to continue at an increasing pace well into the next century, perhaps outstripping our scientific, economic and social ability to cope with them.

**Tingju Zhu, Jay R. Lund, Marion W. Jenkins, Guilherme F. Marques, and Randall S. Ritzema, *Climate Change, Urbanization, and Optimal Long-term Floodplain Protection***

**Abstract:** This paper examines levee-protected floodplains and economic aspects of adaptation to increasing long-term flood risk due to urbanization and climate change. The lower American River floodplain in the Sacramento, California metropolitan area is used as an illustration to explore the course of optimal floodplain protection decisions over long periods. A dynamic programming model is developed and suggests economically desirable adaptations for floodplain levee systems given simultaneous changes in flood climate and urban land values. Economic-engineering optimization analyses of several climate change and urbanization scenarios are made. Sensitivity analyses consider assumptions about future values of floodplain land and damageable property, along with the discount rate. Methodological insights and policy lessons are drawn from modeling results, reflecting the joint effects and relationships that climate, economic costs, and regional economic growth can have on floodplain levee planning decisions.

**Other Peer-Reviewed Scientific Papers**  
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